Using the Booster to Accelerate a Low-Emittance Beam

—SRFEL-003 Addendum—

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In looking at SRFEL-003 with Lee Teng and Louis Emery, it seemed that since the shortest gain lengths for the FEL were at 800-1000MeV, there may be no reason to use a low emittance booster lattice. After all, at these energies, the emittance is dominated by the emittance of the injected beam.

The possible problem with this is the difference in momentum compaction factors. This forces use of a longer bunch length in the low emittance case. Recall that I assume a constant 9MV RF voltage. The momentum compaction factor of the low-emittance lattice is 0.00147, whereas the nominal lattice has 0.00969. The bunch length goes like $\sqrt{\alpha_c}$, so the low emittance lattice is better by a factor of 2.6.

I ran an **elegant** simulation of the nominal booster lattice to get the beam parameters vs energy and ran the result through **sddssasefel**, just as I did for the low emittance lattice. The beam parameters are shown in Figures 1 through 3, while the FEL performance for those cases where the saturation length was under 100m are shown in Figure 4.

One sees that the FEL results are not as good as for the low-emittance booster lattice. At the low end of the energy range, the saturation length for the low-emittance case is about 25m, compared to 40m for the nominal lattice. The low-emittance lattice allows reaching the 2-4nm water window, albeit with a 100m undulator.

FIGURE 1. Emittance vs energy for the nominal booster lattice an 2nm injected emittance at 450MeV

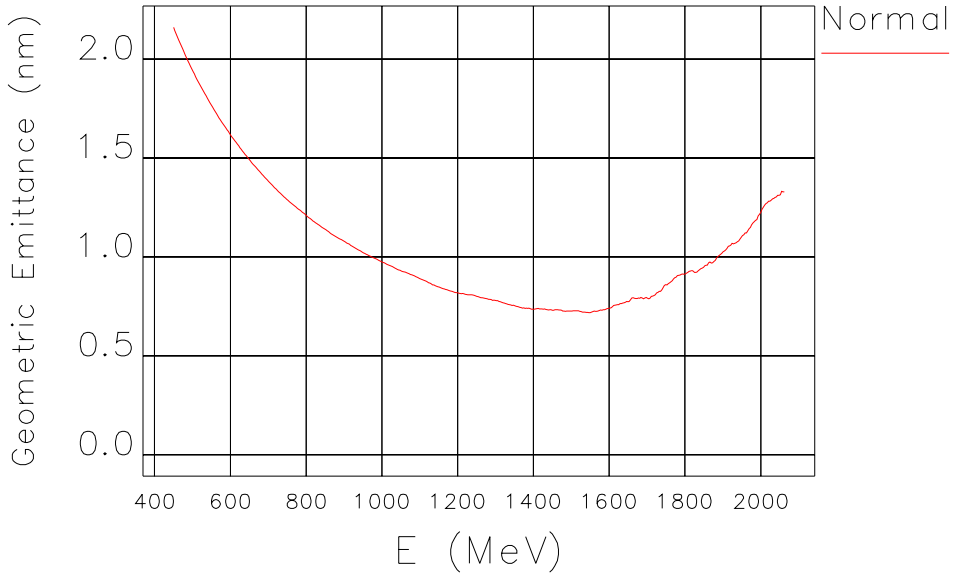

FIGURE 2. Bunch length vs energy, where the initial bunch length is chosen to match 9MV rf voltage at 450MeV with +/-0.190MeV initial energy spread.

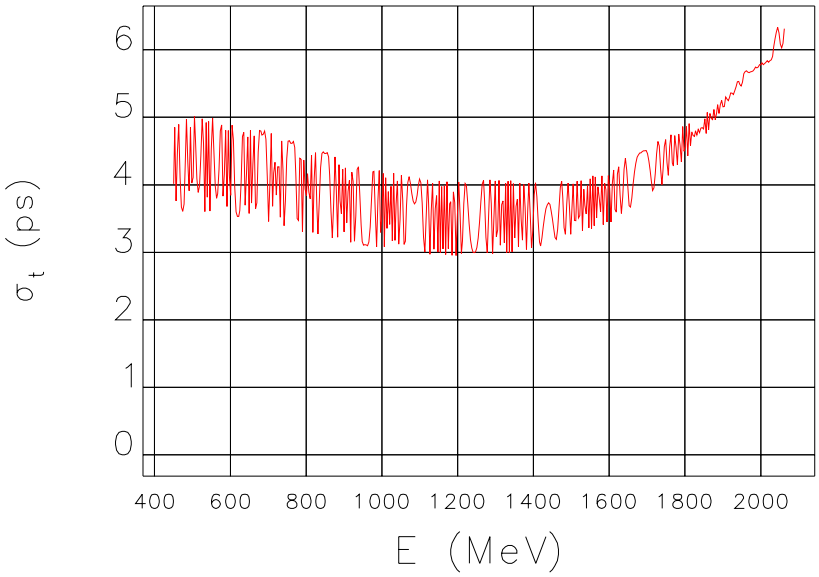

FIGURE 3. Energy spread vs energy corresponding to figure 2.

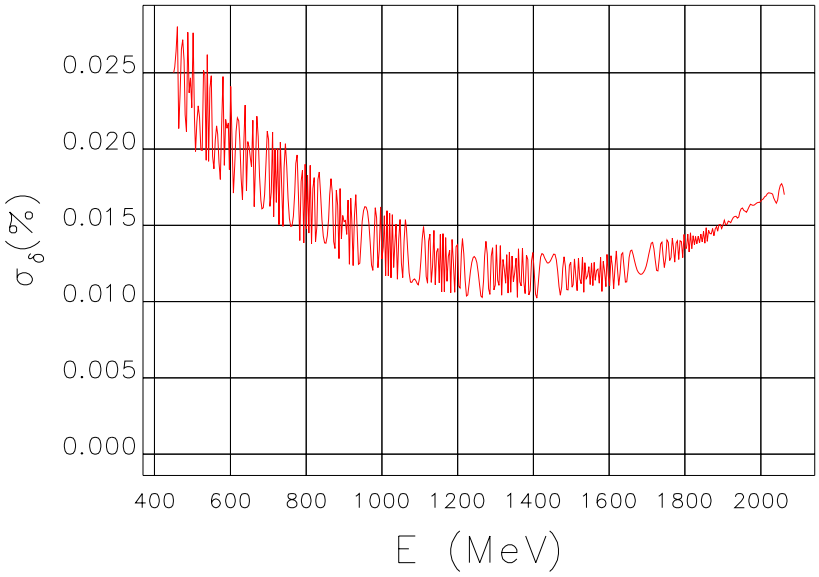

FIGURE 4. FEL performance for beam extracted from booster at various energies, for cases where the saturation length is under 100m.